

OBSERVATIONS ON THE LIPID CONSTITUENTS OF
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Dehydrated potatoes under certain storage conditions develop an off flavor which has been described as rancid, stale or hay-like.

Burton (2) reported that two types of deterioration could be detected in mashed potato powder which had been stored at different temperatures: First, the development of a brown color and charred taste and secondly, the development of an "off" flavor. He also found that increasing the storage temperature tended to accelerate the formation of both, but at the higher temperature the "off" flavor was masked by the charred taste. A high moisture content seemed to promote the first type of deterioration and retard the second.

In another paper Burton (3) ascribed the development of the "off" flavor to oxidation of the potato fat and presented as the basis for his conviction this evidence: (a) The fat was very unsaturated, having an iodine number in the region of 130. (b) Oxygen was absorbed during storage with only a negligible production of carbon dioxide. (c) Storage in an atmosphere of nitrogen inhibited the formation of the "off" flavor. (d) Increasing the moisture content also retarded the development of "off" flavor. This same effect is evidenced by the protective influence of high moisture content in retarding the fat oxidation in wheat flour and dried milk. (e) The development of "off" flavor was greatly accelerated by light which frequently enhances fat oxidation. (f) In some low-moisture samples the "off" flavor was accompanied by an increase in epiphydrin aldehyde as detected by the Kreis test.

Volksen (7) conducted some preliminary experiments on potato fat and ascertained the presence of linoleic, linolenic and palmitic acids from the melting points of their derivatives.

Winton and Winton (8) state that potato fat is present in an amount of 0.02-0.18 per cent of the fresh whole tuber.

Though the amount of fat present may be negligible from a nutrition standpoint, it is still sufficient to induce spoilage from rancidity. Therefore, the purpose of this investigation was to make a more detailed study of the character of potato fat to determine its susceptibility to oxidation and its role in the development of "off" flavors in stored dehydrated potatoes.

EXPERIMENTAL PROCEDURE

The raw material used for this study was white Katahdin potatoes grown in Aroostook County during 1952.

Lipid recovery. Using vacuum dried potatoes, approximately 50 pounds of sound, whole tubers were peeled in an abrasive peeler, diced into $\frac{3}{8}$ inch cubes, washed in cold running water till free of surface

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starch and blanched for 6 minutes in boiling water. These potatoes were then dried in single layers in a vacuum oven maintained at 167°F. (75°C) and a 27.5 inch vacuum, to an approximate moisture content of 5 per cent. The dried potato cubes were ground in a burr mill to a size that passed through a 20 mesh screen and then extracted with petroleum ether (B.P. 35-60°C). Anhydrous sodium sulfate was allowed to remain in contact with the ether-lipid solution overnight to remove traces of water. The solution was then filtered twice through Whatman filter paper No. 40 and distilled under vacuum to recover the lipid material.

Using air-dried potatoes, 420 pounds from the same lot of Katahdin potatoes were given the same preliminary treatment as described for the vacuum-dried potatoes with the exception that these were dried in a forced-air tunnel dehydrator at a dry bulb temperature not exceeding 167°F (75°C). The final moisture content was determined by the vacuum oven method to be 5.3 per cent. The same procedure was employed for extracting the fat as that followed for the vacuum-dried potatoes. Forty-four and one-tenth grams of a brownish-yellow lipid material was obtained which represented a yield of 0.17 per cent on the dry basis and 0.02 per cent on the fresh whole basis less skin.

A portion of the lipid material dissolved in petroleum ether was adsorbed on a column consisting of a mixture of magnesium oxide and hyflo-supercel. Three colored bands appeared; an orange band, a pink band, and a yellow band. Elution with acetone removed the yellow band and the carotene content of the lipid was determined to be 0.022 per cent. The orange band and pink band remained unidentified. The lipid had an odor that could be best described as "earthy." Its consistency at room temperature was thick and viscous. This lipid was stored in a glass-stoppered flask under a nitrogen atmosphere, and kept in a refrigerator at 35.6°F (2°C) until further analysis.

Methods of Analysis. Unsaponifiable matter was determined by the procedure described by Jamieson (5). A reddish-orange substance was obtained with a resinous or varnish-like odor.

Upon removal of the unsaponifiable matter, the total mixed fatty acids were recovered by acidifying the aqueous layer containing the saponified material with a strong excess of 20 per cent sulfuric acid solution and extracting the acidified mixture with low-boiling petroleum ether. The petroleum ether extract was washed free of mineral acid, dried over anhydrous sodium sulfate, and finally, the solvent was removed by vacuum distillation. The fatty acids from both the vacuum-dried and air-dried potatoes were analyzed by a spectro-photometric technique (4).

The acid number of the mixed fatty acids was derived by a method very similar to that described by Jamieson (4), but which had been adapted to small samples by an E.R.R.L. modification.

The acid number was converted to neutralization equivalent (mean molecular weight of the fatty acids) by dividing the equivalent weight of potassium hydroxide in milligrams by the acid number.

The iodine number of the mixed fatty acids was determined at the E.R.R.L. by the Wijs method. Iodine numbers on other samples of mixed fatty acids were determined by the writer using the Hanus method.

The refractive index of the potato fat was obtained with an Abbe

refractometer in accordance with the procedure outlined in the A.O.C.S. (1).

The Fryer and Weston method (1) for determining the specific gravity of the fat was modified. A reference temperature of 59°F (15°C) was maintained and the density of the test solutions was adjusted with sodium chloride. The density of the solution in which the fat sample remained suspended was regarded as the specific gravity of the fat.

An accelerated stability test was conducted on the potato fat in a Fisher Isotemp oven maintained at 148°F (64.5°C). Peroxide values were determined by the Wheeler method as adapted by Riemenschneider *et al.* (6) for small samples. For comparison, parallel tests were conducted on a relatively unstable oil (olive) and a high-stability cooking fat (Swift's Triple X Vream).

Storage studies were conducted on defatted, dehydrated potato granules and control samples packed in screw-cap glass jars and No. 2 hermetically sealed plain tin cans. All samples were stored for 12 months at -0.4°F (-18°C), room temperature and 98.6°F (37°C). The moisture content of all was approximately 6 per cent.

RESULTS AND DISCUSSION

The composition of the lipid material from both vacuum-dried and air-dried potato is presented in table 1. The lipid material gave a positive test for carbohydrates and also for sterols. The fact that the specific gravity is greater than one may seem unusual, but this could possibly be attributed to the high percentage of unsaponifiable matter. No sharp line of demarcation could be obtained in recording the refractive index, consequently the average of twelve readings was taken as the representative value.

The composition of the fatty acids from the two lipids is reported in table 2. Traces of performed conjugation were detected in the fatty acids indicating possibly that slight oxidation had occurred, but with fatty material containing linoleic and linolenic acids, it is rather difficult to

TABLE 1.—Composition of potato lipid.

	Vacuum-dried Potato	Air-dried Potato	
	Sample No. 1	Sample No. 2	Sample No. 3
	E.R.R.L.*	E.R.R.L.*	M.A.E.S.**
	Per cent	Per cent	Per cent
Unsaponifiable matter	13.95	11.5	12.37
Total mixed fatty acids	50.18	56.2	52.7
Ether insoluble	8.34	9.6	9.4
Water soluble after saponification	27.5	22.7	24.3
Refractive index 60°C.	1.4801
Specific gravity 15°/15°	1.0180

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TABLE 2.—*Composition of the fatty acids of potato lipid.*

	Vacuum-dried Potato	Air-dried Potato	
	Sample No. 1	Sample No. 2	Sample No. 3
	E.R.R.L.*	E.R.R.L.*	M.A.E.S.**
	Per cent	Per cent	Per cent
Linoleic acid	41.3	39.1
Linolenic acid	28.4	32.2
Oleic acid	6.9	1.8
Saturated acids	23.3	27.0
Iodine number	158.9	160.1	128.5
Acid number	199.8	193.3
Neutralization equivalent	280.7	290.4

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avoid slight oxidation. There appears to be no significant difference in composition between the two samples of fatty acids to indicate that the air-drying operation had any deleterious effect on the character of the lipid. However, it is interesting to note that a sample of the fatty acids from air-dried potato analyzed at the Maine Agricultural Experiment Station yielded an iodine number (Hanus) of 128.5 which would imply that some oxidation of the lipid had resulted from the air-drying operation. The high neutralization equivalent indicates that a large percentage of the fatty acids are of the order C_{18} . This value is much greater than would be expected for fatty acids from normal fat.

Results of the accelerated stability test are illustrated graphically in figure 1. Regarding olive oil as a relatively unstable oil, the fact that the stability curves for the olive oil and potato lipid practically coincide would seem to imply that the potato lipid is also of an unstable nature. Vream, which is rated as a stable fat, was still in the induction stage at the end of forty days incubation.

No "off" flavor or aroma typical of fat oxidation could be detected in any of the dehydrated potatoes packed in tin containers at any of the various incubation temperatures after a year's storage. However, in the samples held at room temperature and 98.6°F (37°C), a burnt flavor was present which was more pronounced in the controls and which was stronger at the higher temperature. It is possible that the "off" flavor was present and was masked by the burnt flavor. The refrigerated samples had a normal potato odor and aroma. Also, at these same temperatures the controls were slightly darker than the defatted samples. An "off" flavor and aroma did develop in the glass packed controls at room temperature and 98.6°F (37°C), but not in the defatted samples.

SUMMARY AND CONCLUSION

The composition of potato lipid was ascertained and the presence of linoleic, linolenic and oleic acids was revealed in large amounts which

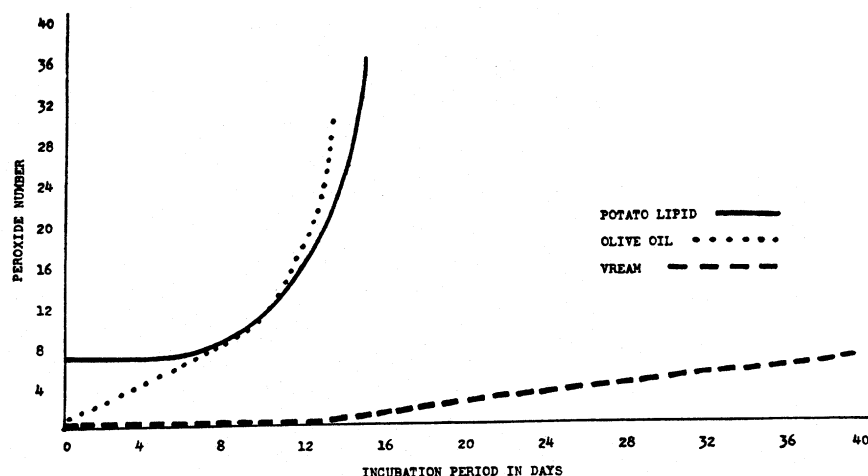


FIGURE 1.—Results of the accelerated stability test.

signified that the lipid had a highly unsaturated structure. Further evidence to support this indication was the determination of the iodine number of the fatty acids to be 158-160. Also, in an accelerated stability test conducted on potato lipid, olive oil and Swift's Triple X Vream at 148°F (64.5°C), the curve for the potato fat was almost superimposed upon the curve for olive oil which is regarded as an unstable oil.

Therefore, in view of these findings, it is proposed that the "off" flavor developed in dehydrated potatoes on prolonged storage results in part from the oxidative rancidity of the lipid material.

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